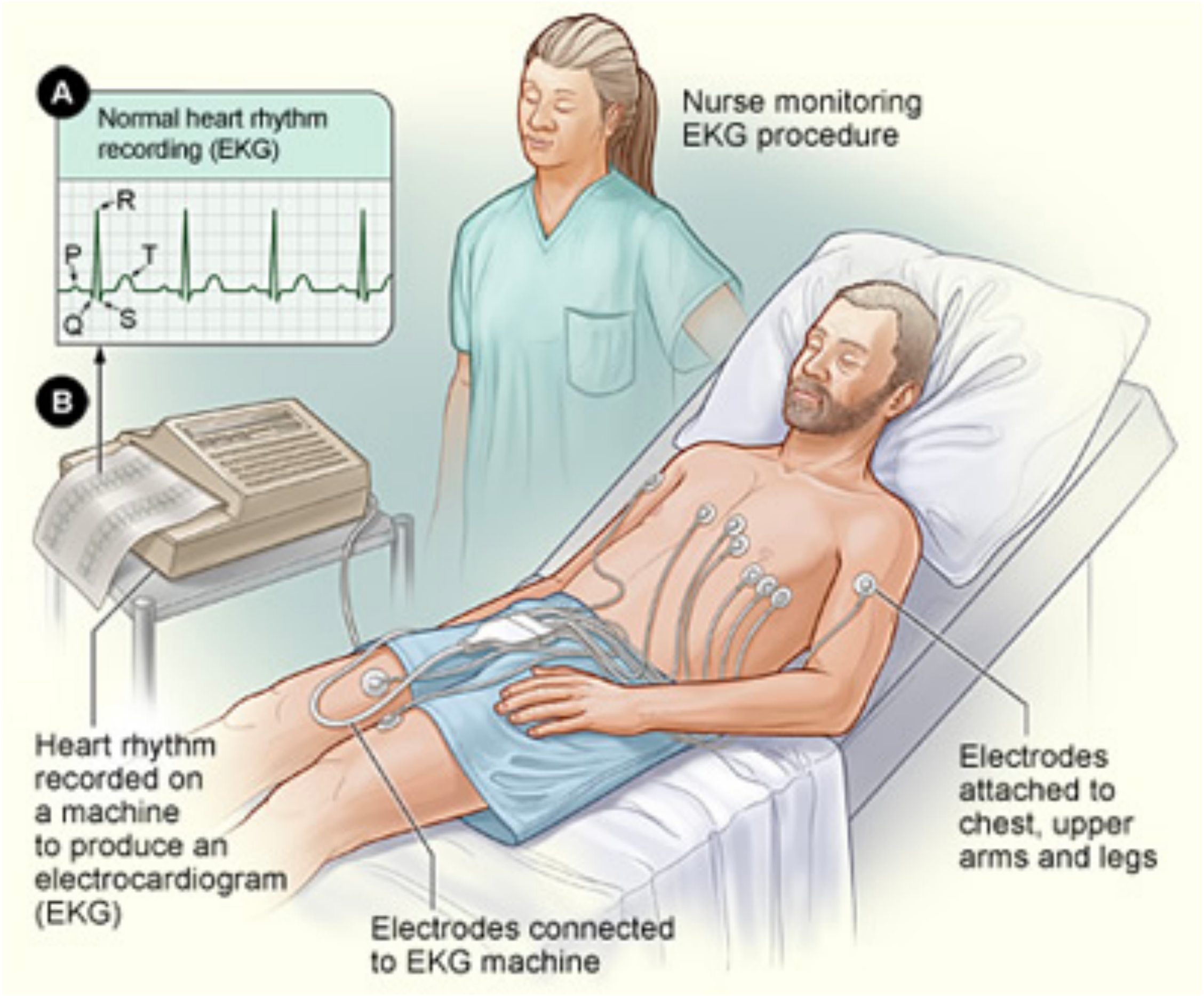
Electrocardiogram (ECG) Detection with Convolutional Neural Network

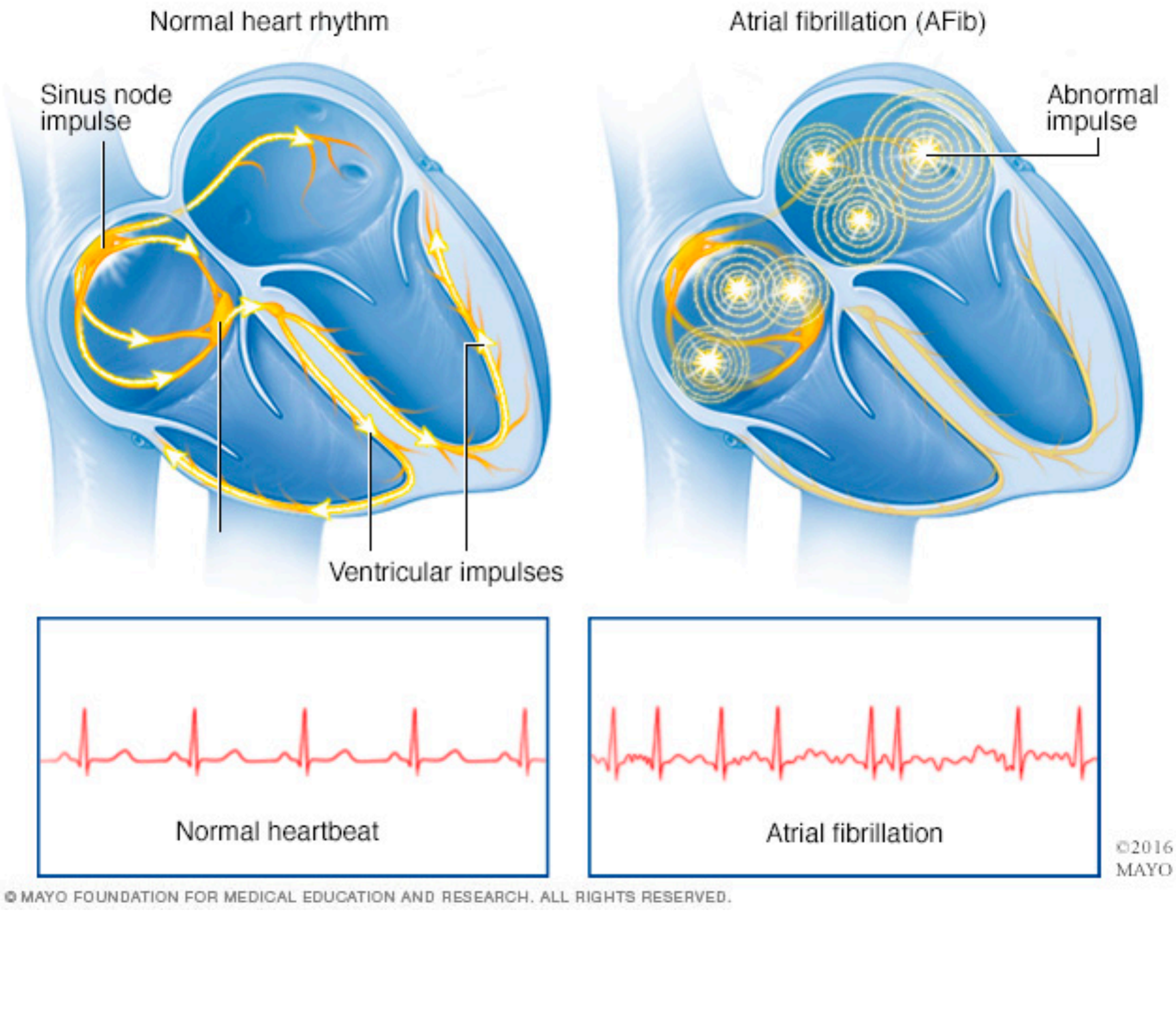
Wen Zhang

https://github.com/gogowenzhang

https://www.linkedin.com/in/wenzhang886/


A
Normal heart rhythm recording (EKG)
R
P
T
Q
S
B
Nurse monitoring EKG procedure
Heart rhythm recorded on a machine to produce an electrocardiogram (EKG)
Electrodes connected to EKG machine
Electrodes attached to chest, upper arms and legs

ATRIAL FIBRILLATION(AF)

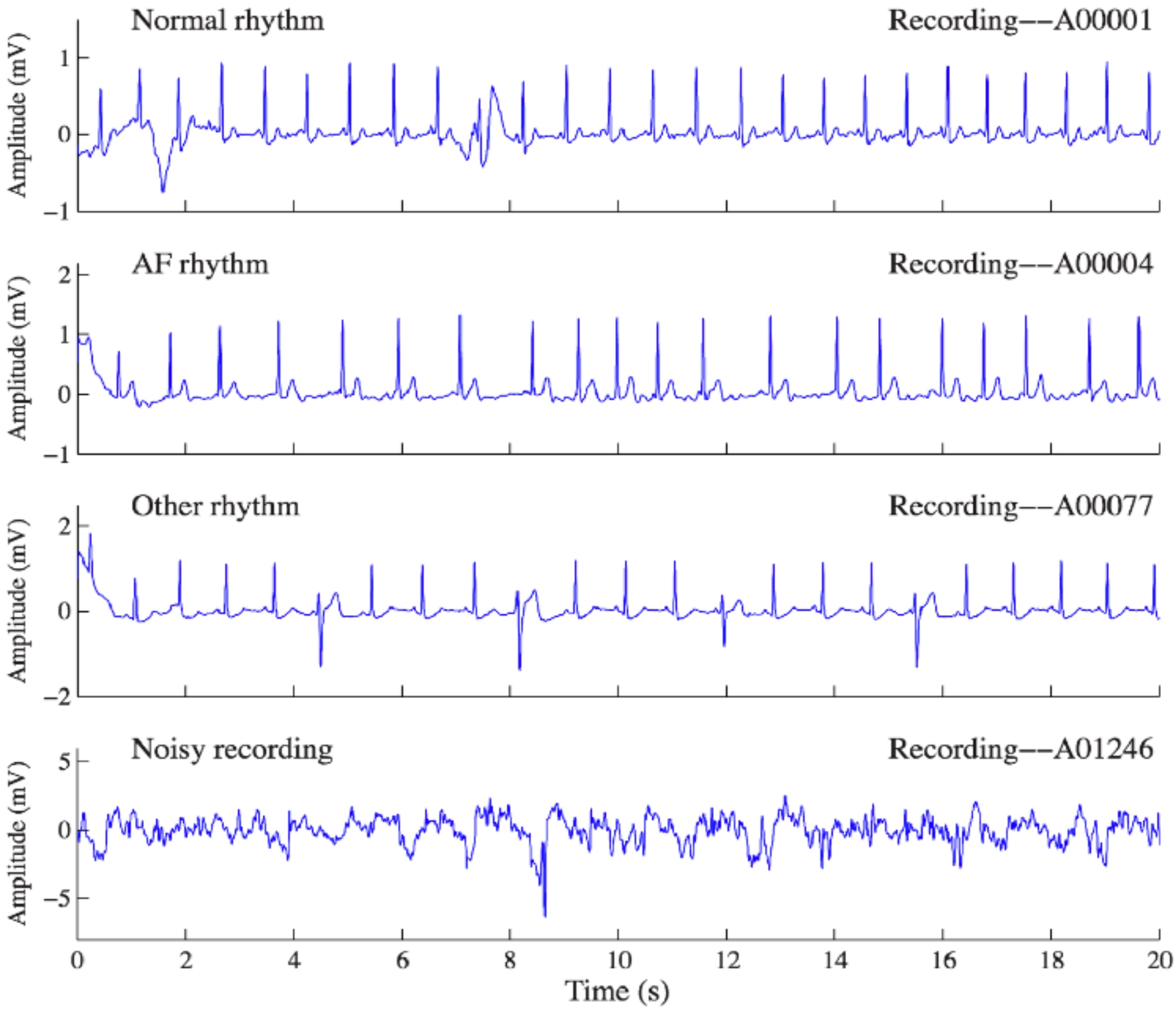


DATASETS

- 8331 samples of 30s single-lead ECG recordings - 1D array
- `array([-0.127, -0.162, -0.197, ..., -0.018, -0.022, -0.021])`
- Label 4 classes

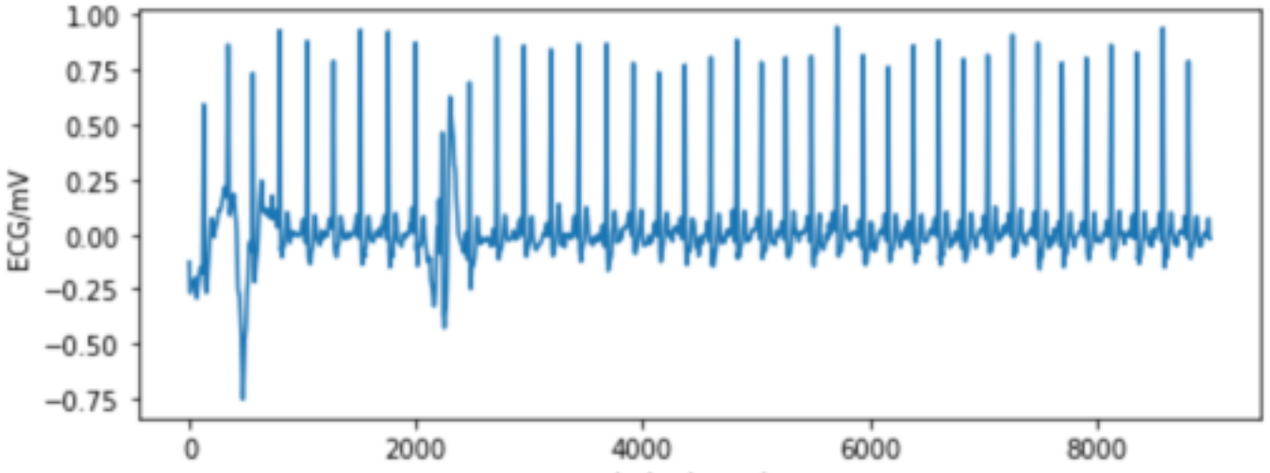
Type	# Recordings	%
Normal	4911	58.95
AF	742	8.91
Other rhythm	2528	30.33
Noise	150	1.80
Total	**8331**	**100.0**

*Labeling: given by AliveCor, 10% over-read by physicians.

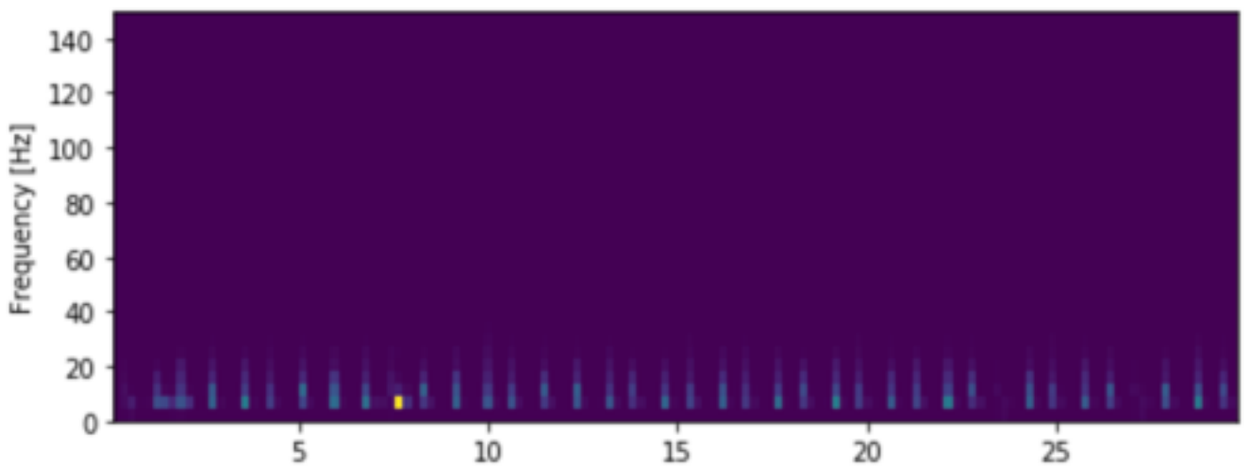

Normal rhythm
Recording––A00001
Amplitude (mV)
1
0
−1
AF rhythm
Recording––A00004
Amplitude (mV)
2
1
0
−1
Other rhythm
Recording––A00077
Amplitude (mV)
2
0
−2
Noisy recording
Recording––A01246
Amplitude (mV)
5
0
−5
0
2
4
6
8
10
12
14
16
18
20
Time (s)

DATA PROCESSING

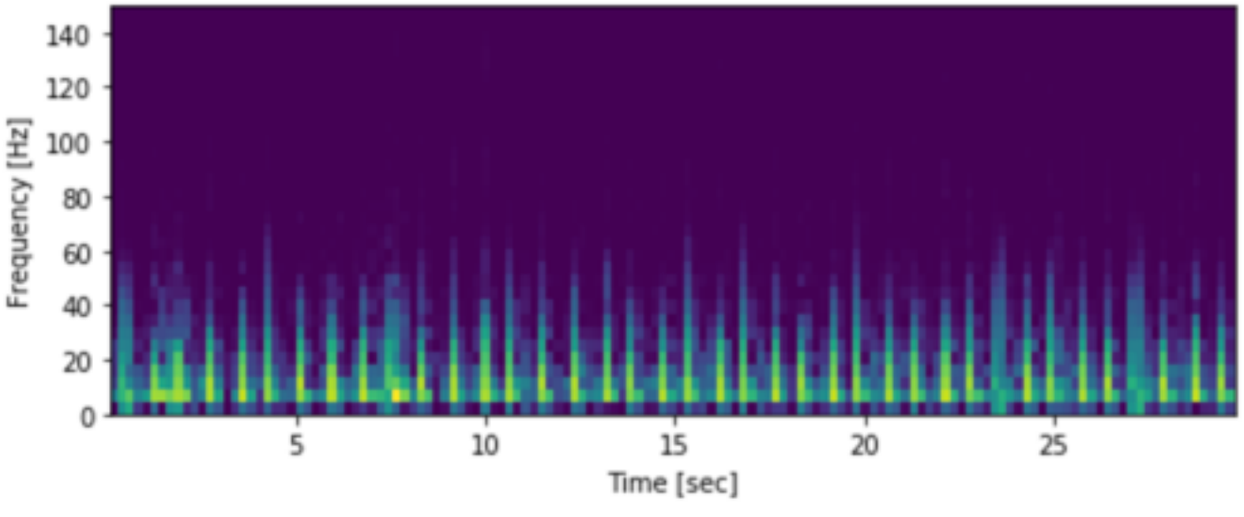
Original Recording



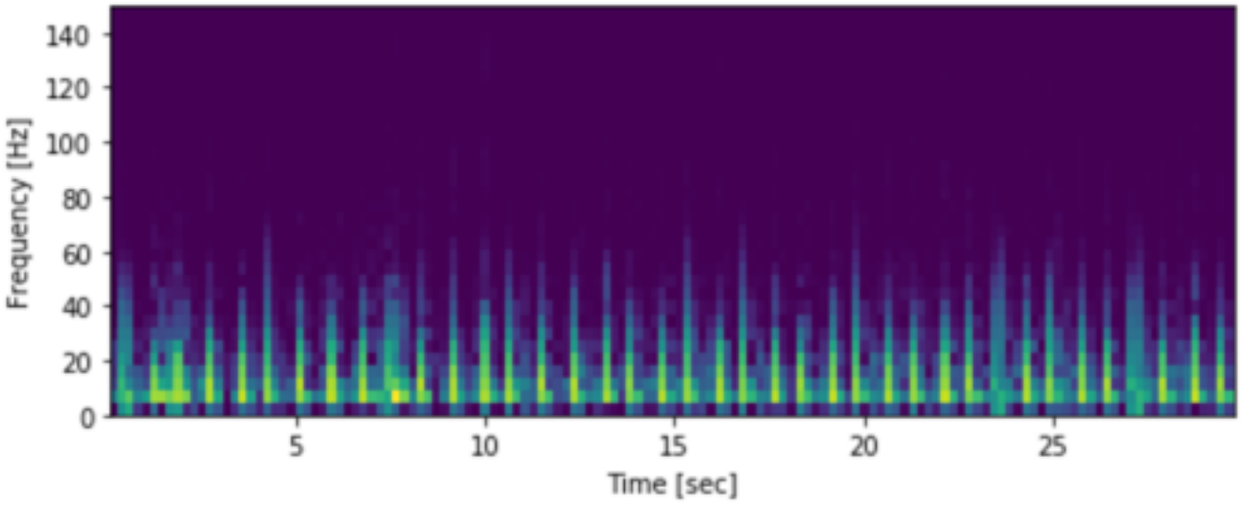
Spectrogram



Log Transformation

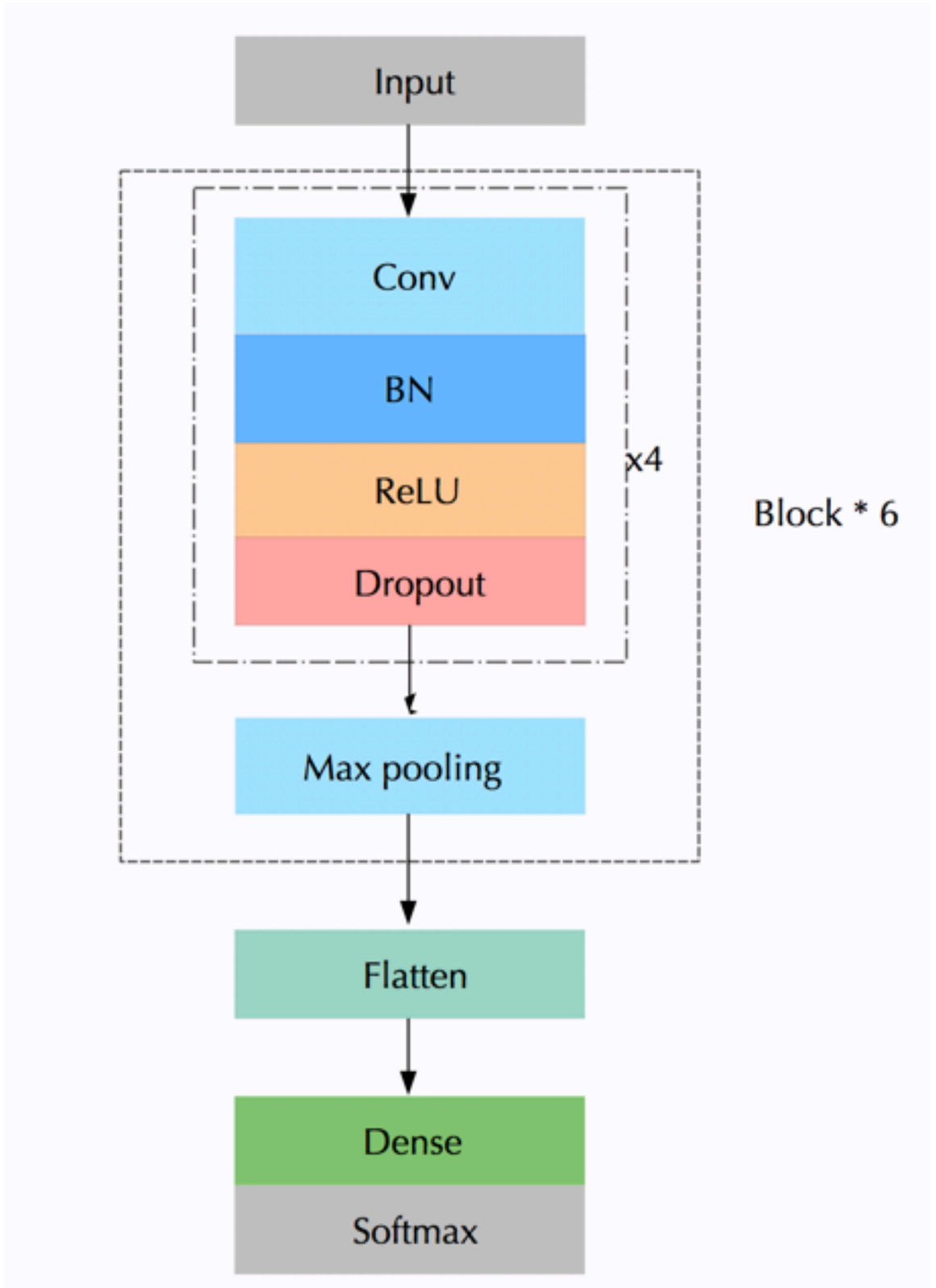


Standardization



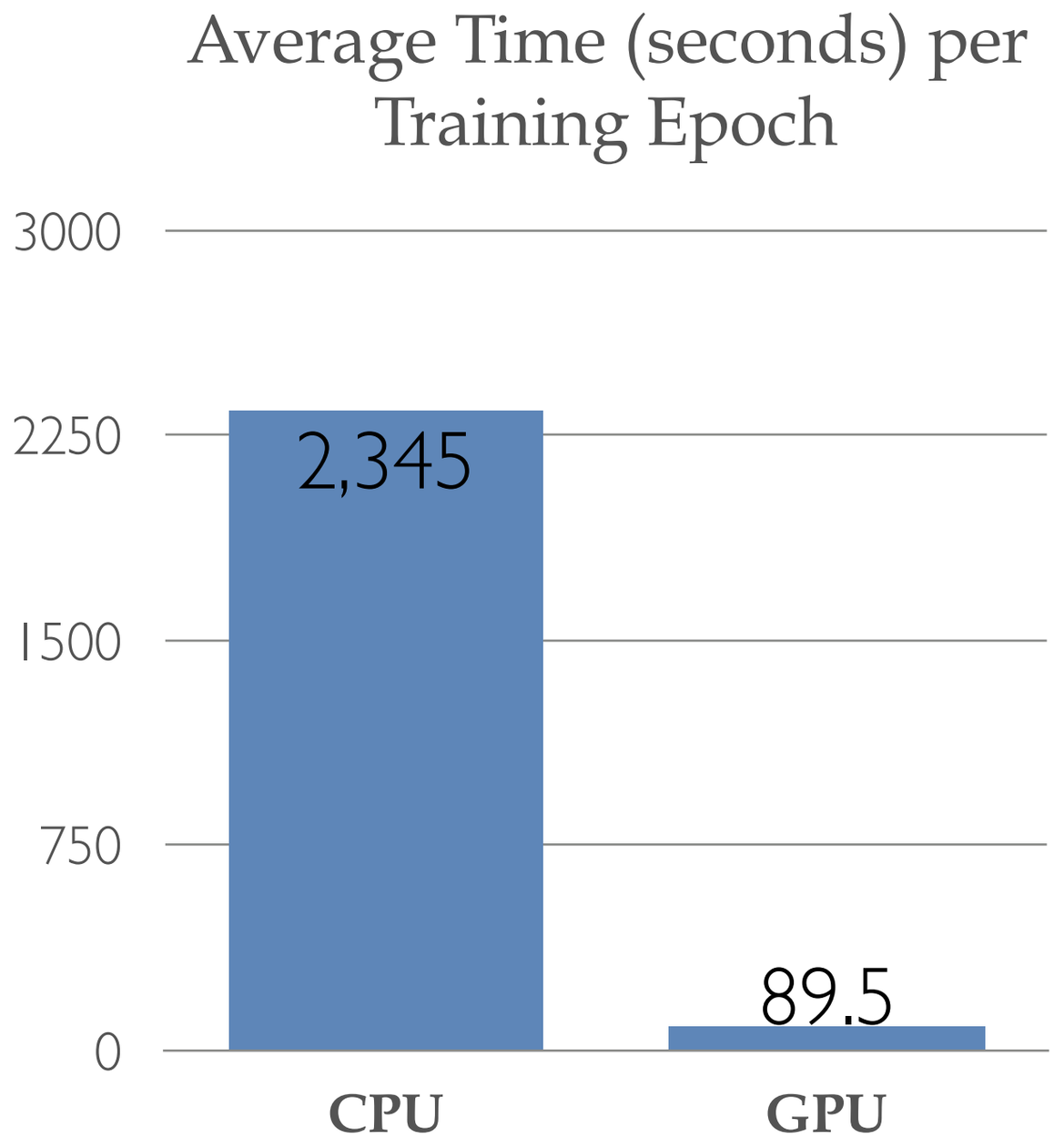
MODEL ARCHITECTURE

- 24-layer convolutional neural network
- Architecture is inspired by (Pranav Rajpurkar et al., 2017) and (Martin Zihlmann et al., 2017)'s work



MODEL TRAINING

- Loss function: cross entropy
- Optimizer: Adam
- Batch size of 20 and 200 epochs.
- Used Keras with Tensorflow backend.
- Models were trained on AWS EC2 P2 instance with NVIDIA Tesla K80 GPUs.



EVALUATION

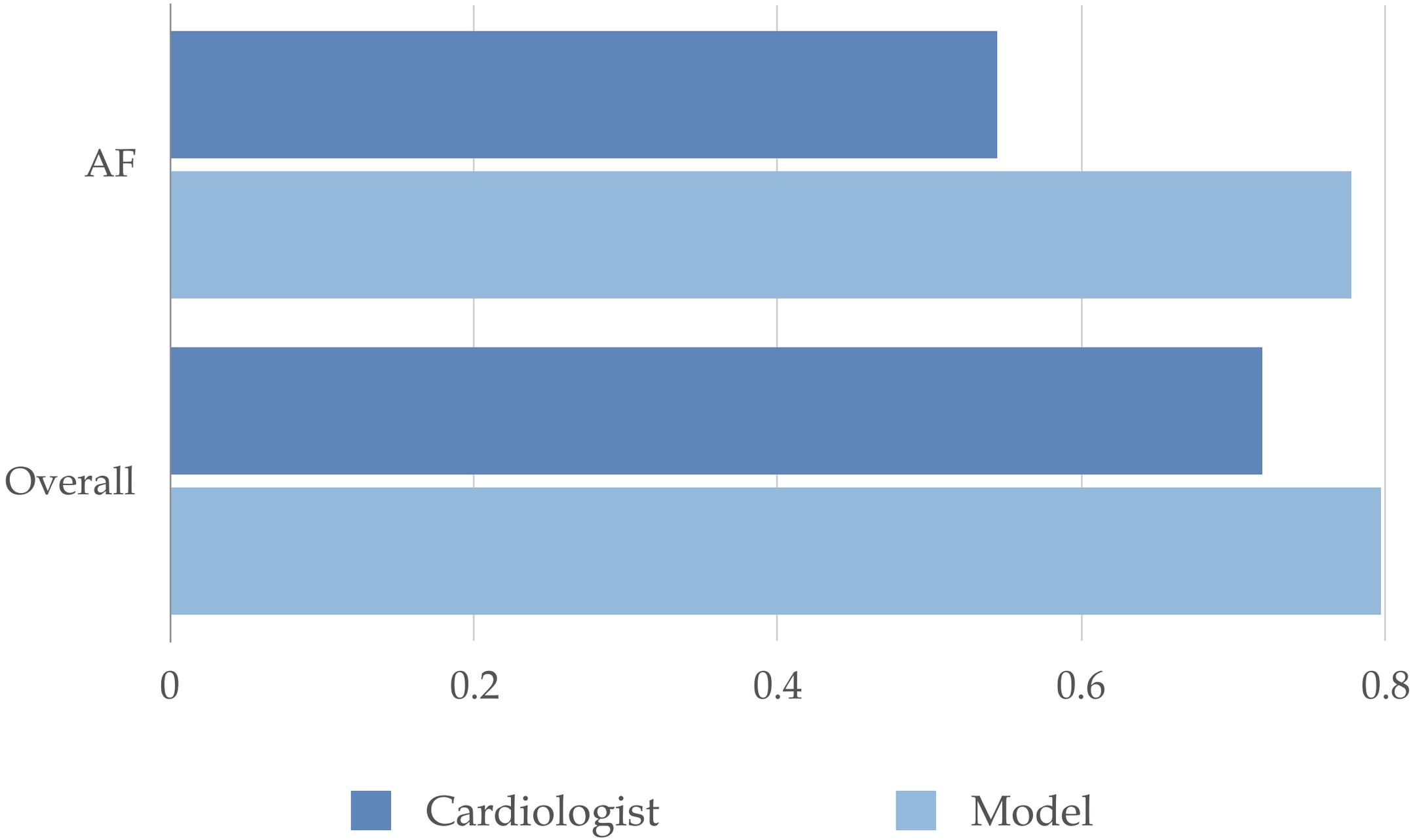
- 5-fold cross validation

$$F1 = \frac{2 \times precision \times recall}{precision + recall}$$

$$F1_{Overall} = (F1_{Normal} + F1_{AF} + F1_{Other}) / 3$$

Metric	Normal	AF	Other	Noise	Overall
Precision	87.3	73.7	75.1	81.8	-
Recall	89.4	80.9	71.0	37.5	-
F1	88.3	77.1	73.1	51.4	79.5
Accuracy	-	-	-	-	81.8

Comparison of F1 score between Cardiologist and Model



TAKEAWAYS

- Spectrogram + CNN is powerful.
- Standardization of input image is important for CNN.
- Batch normalization helps optimization.
- Learning rate and dropout rate are crucial in model convergence.
- Training a CNN is computationally expensive.

LIMITATIONS

- Larger sample size needed.
- Data augmentation has not been applied.
- Only takes in fixed length of recordings. Method to deal with arbitrary length input should be implemented.
- LSTM tested individual and combined, neither come to better performance. Further investigation needed.
- Experiments needed to validate the causal effect.

IN THE FUTURE

- To investigate extending the set of arrhythmias and other forms of heart disease.
- To equip wearable device with real-time detection and save life.
- Map ECG to emotional status would be an interesting topic.